TEXAS AGRICULTURAL EXPERIMENT STATION
A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 472 DECEMBER, 1932

DIVISION OF AGRONOMY

Alfalfa Production Under Irrigation in Western Texas

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†As of December 1, 1932.
††On leave.

Alfalfa is one of the best cash and forage crops for the irrigated sections in western Texas. The crop succeeds best on deep loam soils having good drainage. Over a period of years, fall seeding, about September 20, at the rate of 16 to 20 pounds per acre has given the largest yields of hay at the Experiment Station at Balmorhea. The common variety of alfalfa is the most dependable variety for the region.

Usually five cuttings, with an average yield of one ton of hay per acre for each cutting, are obtained each year.

Where a seed crop is desired, the alfalfa is allowed to mature seed after the first cutting. An average yield of 400 to 500 pounds of seed per acre may be expected.

Under the conditions at Balmorhea with an average rainfall of 14.48 inches, the water requirement of the alfalfa crop is approximately 48 inches a year. Usually an irrigation of 4 to 6 inches is given immediately after each cutting.

Rescue grass, Johnson grass, and Bermuda grass are the worst weeds in alfalfa fields. Cotton root rot is the most serious disease of alfalfa. A rotation consisting of 4 years of cultivated crops, such as cotton and sorghum, followed by a small grain, and 5 years of alfalfa will aid in eradicating the weeds and disease.

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ALFALFA PRODUCTION UNDER IRRIGATION IN WESTERN TEXAS

JOHN J. BAYLES

The alfalfa crop in Texas did not receive the attention which it merited during the years when cotton brought a high price. This has probably been due, at least in part, to the fact that in areas where it has been grown it has been considered as a cash crop to be shipped to distant points, rather than as a feed crop to be fed to livestock on the farm where it is produced. During the period of high cotton prices, much of the acreage in alfalfa was plowed up and planted to cotton, but with low-priced cotton this acreage is again being planted to alfalfa, with the prospect that a large additional acreage will also be planted to this crop, finest of all forage crops. A definite livestock feeding program, which will include alfalfa, is likely to be started on many farms. The adoption of a rotation including alfalfa, where it is adapted, is one sure method of building up soil fertility and maintaining high yields of other crops.

PRINCIPAL AREAS IN TEXAS GROWING ALFALFA

In western Texas large areas of land are suitable for alfalfa production, but in the extreme western part of the State the acreage which can be grown is limited to those areas having water available for irrigation from streams, storage reservoirs, flowing springs, as at Fort Stockton and Balmorhea, or shallow underground water which can be pumped to the surface at a reasonable cost. A few areas are naturally sub-irrigated but these are very limited. The irrigated areas are widely scattered but, in general, are found in the valleys of the Rio Grande, Pecos, and Red rivers, and in Hale and some other counties where shallow water is available for pump irrigation. A considerable acerage of alfalfa is produced without irrigation along the Red River and throughout a belt extending southward from Grayson to Wharton County.

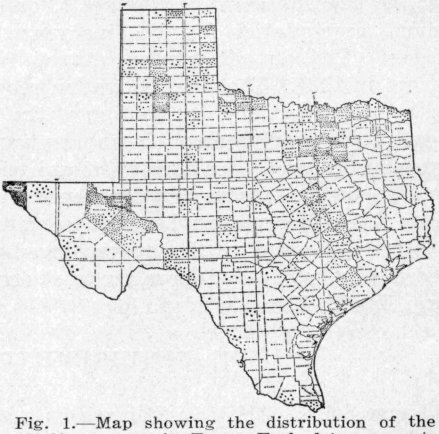

Fig. 1.—Map showing the distribution of the alfalfa acerage in Texas. Each dot represents 25 acres.

According to the U. S. Census of 1930 there were 50,219 acres of alfalfa in Texas. The distribution of this acreage is shown in Figure 1.

CLIMATIC ADAPTATION OF ALFALFA

Alfalfa reaches its maximum commercial development in sections favored by moderately high temperatures, abundance of sunshine, warm nights, relatively low humidity, low annual rainfall, and in dry sections where

water may be supplied by irrigation. In Texas these requirements are most nearly met with in the irrigated valleys and plains of the western part of the State. However, many fields of alfalfa are now being successfully grown in central Texas and eastward, without irrigation. Under humid conditions the crop is more subject to diseases, such as leaf spot and root rot, and to damage by weather, and fields are short-lived because growing conditions are more favorable for grass and weeds and less favorable for the alfalfa.

Table 1—Monthly and annual precipitation in inches at Balmorhea, Texas—1923 to 1931

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1923	.87	2.14	.89	.43	.09	1.22	3.97	4.62	.90	1.48	1.48	2.17	20.26
1924	T	1.98	.33	.46	.02	T	1.50	.21	2.64	1.74	T	.23	9.11
1925	T	.00	.00	2.22	1.43	.13	2.13	3.73	2.27	2.65	T	.09	14.65
1926	.59	.00	1.68	.75	1.50	1.36	2.60	2.68	2.09	2.69	.74	1.62	18.30
1927	.13	.44	.63	T	.37	.54	.94	.46	3.74	.37	.00	.58	8.20
1928	.01	.12	.03	.39	1.33	.66	4.97	4.62	3.06	.93	.64	.12	16.88
1929	.00	.77	.93	.84	1.28	1.33	.59	.92	2.13	1.81	.33	.23	11.16
1930	.32	.16	.47	1.50	.93	4.87	.72	2.82	.47	1.98	.85	.73	15.82
1931	1.13	.90	.89	3.47	1.35	1.69	1.25	1.47	.43	.21	.86	2.25	15.90
Average annual													14.48

The total annual precipitation in western Texas fluctuates greatly from year to year, as shown in Table 1. For example, at Balmorhea the average annual precipitation for the nine years, 1923 to 1931, inclusive, was 14.48 inches. The annual rainfall ranged from 8.20 inches in 1927 to 20.26 inches in 1923. The total irrigation requirements of a crop vary inversely with the amount and distribution of the rainfall. The lower water requirement during wet seasons is due, in part, to the water added to the soil by rainfall, and to the higher atmospheric humidity and lower rate of evaporation during seasons of more abundant rainfall. Less irrigation water is required during years when the precipitation for June, July, August, and September is heavy. During prolonged periods of drought the atmosphere becomes very dry and more frequent irrigations are necessary to keep the crop in a thrifty condition.

SOIL REQUIREMENTS OF ALFALFA

Loam Soils: Alfalfa will grow on a wide variety of soils but will make its best growth, with the least amount of water, when produced on deep loam, or sandy loam soils which are well drained. These soils allow irrigation water to penetrate quickly to a depth of five or six feet and favor the development of deep tap roots, which enable the plants to draw moisture from a depth of several feet.

Sandy Soils: Some difficulty is usually experienced in getting stands of alfalfa established on very sandy soils because of a tendency to damage the young plants by washing and blowing before they become established.

When such fields are to be planted to alfalfa they should be laid out with more fall and shorter lengths of borders; otherwise water will be wasted by penetrating below the alfalfa roots. Such soils can be greatly improved by turning under large amounts of straw, crop residues, and applications of barnyard manure, which will increase the fertility and aid in preventing the soil from washing or blowing.

Heavy Soils: It is harder to obtain a stand on heavy adobe soils than on loam soils. Irrigation water does not penetrate heavy soils easily and it is therefore necessary to give the borders less fall and hold the water longer. These soils have a tendency to crack badly upon drying and there is more danger of killing out alfalfa plants in low places where water stands too long in hot weather. Frequently the root system is shallow on the heaviest soils and there is a tendency for the crop to stop growth early in dry weather unless water is applied frequently. When these heavy soils are used for the production of alfalfa, the borders should be made long enough and the slope gradual enough to provide for deep penetration of irrigation water.

Poor Alfalfa Soils: Under some conditions the top soil may be good, but the good soil may be shallow and underlain with hardpan. Such soils do not provide space for normal root development. Soils having gravel beds within 3 or 4 feet of the surface should be avoided when selecting fields for alfalfa, since much irrigation water will be lost by percolation through these gravel strata.

VARIETIES OF ALFALFA FOR WESTERN TEXAS

Since the alfalfa plant has been grown in many parts of the world under a variety of climatic conditions, many varieties have been developed, each suited to certain conditions. Many of these have been grown over a period of years at Balmorhea. Most of them have been inferior to the common variety generally grown in the irrigated valleys, and only a few have been promising as commercial varieties. Some of these are being increased and if they continue to make a favorable showing in comparison with the common variety, they will be distributed to farmers of the region for a wider test.

Common Alfalfa

The common variety of alfalfa, as grown in the irrigated districts, is not a distinct variety but is generally a mixture of many strains which have been grown under similar climatic conditions over a period of years. Through a process of natural selection the weaker and poorly adapted plants die out and the stronger plants survive. Because of the fact that what is known as common alfalfa comes from so many different sources it is not all superior seed and, if possible, it is best to know the exact source of seed when buying for planting new fields. There is little difference in

the best strains of common alfalfa coming from Arizona, New Mexico, Kansas, Oklahoma, or Texas, and any of these usually will give satisfaction when planted in Texas. If it is impossible to obtain seed directly from a neighbor grower who produces good seed, seed should be secured only through a reputable dealer and should be free of weed seeds. For general planting the best strains of the common variety are likely to prove most profitable.

Hairy Peruvian

The Hairy Peruvian variety is grown extensively in the irrigated valleys of Arizona and to some extent in New Mexico. The seeds of this variety germinate quickly and the young plants make a very vigorous growth as compared with the common variety. On old fields, growth starts earlier in the spring and a little quicker after each cutting than with most other varieties. Yields during the first few years after seeding are a little heavier than for other varieties. However, the plants do not stool and branch as freely as the common variety, and the hay is a little coarser and less leafy and does not have quite as desirable a color as that from other varieties. The coarseness can be overcome to some extent by seeding at the rate of twenty or more pounds per acre. The greatest objection to this variety in the irrigated districts of western Texas is that it is more seriously damaged by the cotton root rot disease than other varieties, and if planted on land infested with this fungus it will be killed out much quicker than the common variety. It seems to have less ability to send out new side roots when the tap root is affected, and a large percentage of the infected plants die. Experience has indicated that the Hairy Peruvian variety should never be planted on land infested with the root rot fungus.

Smooth Peruvian

The plant characteristics of the Smooth Peruvian are similar to those of the Hairy Peruvian, except that the foliage is less hairy. The plants stool and branch sparingly, growth is upright, and the hay inclined to be coarse. There is little to recommend the variety for general planting in Texas.

Grimm

The Grimm variety is similar in appearance to the common variety but is more resistant to low temperatures and has a more branching root system. When grown under irrigation in this section it has made about the same growth as the common variety. In the colder parts of the alfalfa-growing sections of the United States it might be expected to suffer less from severe winters, but in the southern parts results obtained are likely to be about the same as for common alfalfa.

Other Varieties

Many different varieties from foreign countries have been tried with varying results. Selections have been made from the most promising of these but they have not been grown over a long enough period to determine their exact value as commercial varieties now commonly grown in the region.

METHODS OF LAYING OUT FIELDS FOR ALFALFA UNDER IRRIGATION

There are three general methods of laying out fields for irrigating alfalfa in Texas.

Border Method

The border method generally is used where the available head of water ranges from two and one-half to five second feet and the land is comparatively level with a fairly uniform slope. This method consists of dividing the field into long narrow strips, separated by levees which are spaced thirty to forty feet apart, depending upon the size of the irrigating head of water (Figure 2). The levees are laid off on contour lines, regular, if possible, and having a grade of one to three inches per 100 feet for clay soils, two to four inches for sandy loam soils, and three to five inches for very sandy soils. The length of the border may vary from 400 feet to 800 feet, or even longer, but runs of more than 800 feet are wasteful of water, since the soil at one end of the border is likely to be wet down beyond the feeding zone of the roots, while the other is wet down only a few inches.

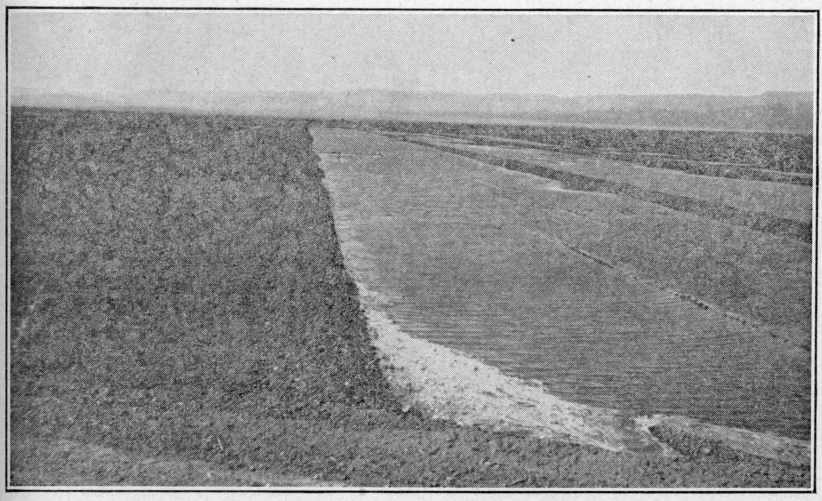

Fig. 2.—Land prepared for irrigation by the border method.

Very little fall should be given for short borders of 400 feet or less. The land between the levees is graded level from one levee to the other so that a head of water will spread across the border to a uniform depth and flow down the slope. It is even better to grade the low side of the border a little higher than the other side, since the loose dirt there is likely to settle more than on the upper side.

After establishing the contour lines the levees may be started by plowing four or six furrows together. One round with a two- or three-disk tractor plow makes an ideal base for a levee. This ridge is dragged and pressed together with a border press drawn by four horses or a tractor. The border press is usually followed again by the plow, which throws another furrow at the base of the levee. About three times over with the border press will usually make a firm, compact levee. The space between the levees is then graded level with a drag or grader. This work should be done carefully and all high points dragged off; otherwise there will be dry spots in the field. With a head varying from two and one-half to four cubic feet per second, the width between levees may be as close as 30 feet, but for loam and clay soils, and the larger heads, usually 36 to 40 feet in width will be more satisfactory.

The cost of preparation for irrigating alfalfa land by the border method is somewhat higher than for the flooding method but where the available head of water ranges from two to five cubic feet per second and the land has a gradual uniform slope, the ease and efficiency with which the water can be handled will more than offset the extra cost.

Flooding Method

On land which is uneven or has too much slope to permit the use of the border method of irrigating alfalfa, the flooding method is frequently used. Under this system the field is laid off with supply ditches on the contour lines. Water is thrown out of the supply ditches by the use of canvas dams, or headgates, at intervals along the ditch. The space between the ditches is then flooded. This method is inexpensive and is well adapted to the irrigation of rough or uneven land, but is wasteful of water and makes an even distribution of water more difficult than with the border method. When the flooding method is used in irrigating rough ground, it is often possible to distribute water to high points by use of a few corrugation furrows to lead the water to these points.

Check Method

Under some irrigation systems in western Texas where flood waters from creeks or rivers are depended upon to irrigate land it is necessary to use large volumes of water over a short period of time, and under these conditions the ditches and irrigation structures are made to distribute large heads, up to 10 or more cubic feet per second. Under these conditions modified borders, or checks, may be used. These are surrounded by levees, and each may contain up to an acre or more of land. Large heads may be

turned into these checks, and they can be irrigated at the rate of one to two acres an hour. Under certain conditions this is a practical system to install for the irrigation of alfalfa.

SEEDING ALFALFA

Time of Seeding

The optimum date of seeding will vary with the latitude, elevation above sea level, and to some extent with the season, but is rather definite for any given locality. When alfalfa is grown by irrigation, fall seeding is nearly always preferable to spring seeding. Weeds and grass are less troublesome then and the young alfalfa plants become firmly established and deeply rooted during the fall and winter months while the grass and weeds are more or less dormant, and when growth starts in the spring the alfalfa starts ahead of the weeds and grass and will make three or four good cuttings the first summer after fall sowing.

If sown during late winter or early spring the humidity is low, high winds are frequent, and weed and grass seeds germinate along with the alfalfa seed and tend to choke out the alfalfa plants throughout the summer. Frequent irrigations are necessary to keep the small, shallow-rooted plants from drying up; the two or three cuttings produced the first summer after spring sowing are largely grass and weeds. Nearly as much work is required for the first season as is necessary to care for a field producing good crops of hay; yet little can be expected in return.

The best date of seeding for the irrigated districts around Balmorhea will vary from September 5 to September 25. If planted much earlier than September 5, the weather is likely to be too hot and dry for the young seedlings to get a good start. If planted much later than September 25, there is danger that many plants will be killed by cold weather before they become well established. This is especially true in severe winters. About September 15 to 20 is usually the most desirable seeding date here. In localities north of Balmorhea, the optimum date of seeding would be earlier in the fall, and in the southern part of the State the crop could be safely seeded later in the season.

Methods of Seeding

Alfalfa is generally seeded broadcast in the Madera Valley, although under some conditions drilling is to be preferred.

Broadcasting: Where the alfalfa is to be seeded broadcast, the field is prepared for irrigation by the border method, the levees are finished, and the land between them is leveled, the high spots being removed and low spots filled with drags and floats. These operations leave a smooth surface of finely pulverized soil which does not make a good seed-bed when left in that condition. A smoothing harrow, or spring tooth harrow, should be run over the ground to roughen the surface slightly and bring a few

clods to the surface. One-half of the seed is sown lengthwise of the border, using a whirling knapsack seeder. The other half of the seed is then sown crosswise of the borders. This insures a uniform scattering of the seed with no skips. The seed drop in the shallow depressions caused by the harrow and are not covered.

After sowing is completed, the field is irrigated. The irrigation water flowing over the ground prepared in this way will cover the seed to about the right depth. If the weather is damp and cloudy, this one irrigation may be all that is necessary to sprout the seed and bring it up, but usually the soil will crust over on the surface before the plants get out of the ground, and for this reason it is usually best to plan on re-watering the field within three to five days. Four days is generally about right during warm weather. If it is re-watered earlier than the third day after the first irrigation the soil is likely to crust over before the plants get out, while if allowed to go more than five days during warm weather the plants which have come out will be covered up and killed.

The broadcast method of seeding has the advantage over the drilling method in that all levees and corners are covered with seed and if a stand is secured, weeds are less troublesome later.

Drilling: Under some conditions the drill method of planting is preferred. When this method is used, the field is leveled and prepared as for broadcasting, but is irrigated about five or ten days prior to planting time. As soon as the soil is dry enough to work, the field is mulched lightly and harrowed smooth. The seed is then planted with a drill adjusted to sow 14 to 16 pounds of seed per acre. If germination is good, this will produce a heavy stand of plants. This method has the advantage of requiring less water for starting the crop but does not produce a stand of plants over the levees and in the corners, and is not generally used in the Madera Valley.

Rate of Seeding

When alfalfa is grown under irrigation, a good stand is necessary to produce high yields and to keep out weeds and grass. For this reason the rate of seeding is usually heavier than for dry-land farming. If the seedbed is well prepared and conditions are favorable, 16 pounds of good seed of the common variety per acre will produce an excellent stand. About 20 pounds per acre of the Hairy Peruvian and similar varieties will be required to give the same stand, since these varieties do not stool heavily. Where the drill method of seeding is used, a little less seed is necessary and 14 to 16 pounds per acre will produce a heavy stand under favorable conditions.

If conditions at the time of seeding are not just right, it is advisable, in order to get a good stand, to plant 2 or 3 pounds more per acre than the usual amount of seed. If the stand is thin, the hay will be coarse and stemmy and grass and weeds will soon get started in the vacant spaces.

Seeding Alfalfa After Cotton or Sorghums

Good stands of alfalfa may often be established in the fall following sorghum or cotton crops which have been well cultivated, provided the sorghum crop has been harvested early, or the vegetative growth of the cotton is small. This method of seeding cannot be generally recommended but there are times when it is desirable to get alfalfa started in the fall following one of these crops.

If the growth of cotton is short and the crop well cultivated and clean, it is often possible to obtain a stand by seeding alfalfa broadcast immediately after the last cultivation during the latter part of August or early September. This seed is irrigated up just as it is when planted alone. The cotton plants produce some shade and draw heavily on the supply of soil moisture. However, if the stand of cotton is not too thick, and the plants are small, there is a good chance of establishing a stand of alfalfa in this way. On fields having a rank growth of cotton the alfalfa plants will be shaded out and killed, and it is useless to attempt seeding on such fields.

Fields which have produced an early sorghum crop are likely to be depleted of both moisture and available plant food, but if they are double-disked and harrowed down, a stand of alfalfa may be secured by seeding a little heavier than usual and irrigating the crop up as pointed out under the border method.

Seeding Alfalfa With Nurse Crops

Under most conditions, seeding alfalfa alone is preferable to seeding with a nurse crop. However, on sandy soils which have a tendency to wash or blow badly, a nurse crop of small grain may aid in holding the soil until the alfalfa plants become established. The principal objections to the use of a nurse crop are: there is some danger that the nurse crop will crowd out the alfalfa; growth of the alfalfa plants will be slow until the nurse crop is removed; and the yield of alfalfa will be light during the first year. Any one of the fall-planted small grains—oats, wheat, or barley—may be used as a nurse crop, but when used in this way the rate of seeding should be only about one-half as heavy as when planted as a grain crop. A reavy stand of grain would kill out much of the young alfalfa.

If oats are used as a nurse crop they should be cut for hay rather than as a grain crop, since, if allowed to ripen and shatter, much of the seed will germinate and produce a mixture of oats in the first crop of alfalfa the following year.

IRRIGATING ALFALFA

If a crop of alfalfa is started in the fall of the year, usually two or three irrigations are needed during the winter months to get the plants established. Two irrigations are required after growth starts in the spring to bring the first cutting to maturity. The last irrigation should be given

about ten days prior to harvesting of the crop so that the top soil may have time to dry out; otherwise the hay will not cure quickly.

Immediately after removing the first crop, the field is again watered to start the new growth. In most soils where the roots of the plants do not reach underground water and where rainfall is light, a second irrigation is needed within eight to twelve days after the first. On such soils the first irrigation will carry the crop until it has made a growth of 10 to 12 inches, but it then begins to suffer for moisture and its rapid growth is slowed up if a second irrigation is not supplied. This slackening in rate of growth is indicated by a deeper bluish-green color, which is quite noticeable to the experienced grower. If maximum yields are to be expected, the crop should not be allowed to reach this dark-color stage, as it will not respond readily to the application of water after becoming stunted.

During the remainder of the season, water is applied about the same as for the first crop, except as the need is modified by rains. The field is usually irrigated immediately after each cutting and again within eight to twelve days unless considerable rain falls. Heavy rains may make the second irrigation unnecessary. On some of the best alfalfa soils one irrigation per crop is sufficient to produce good yields.

The amount of water applied at each irrigation varies with the kind of soil, slope of land, length of run, and amount of growth on the ground, but the average irrigation is four to six inches in depth.

Water should not be allowed to stand on alfalfa for more than a few hours during hot weather, since the hot sun shining on standing water will sometimes scald and kill the plants rather quickly. The quantity of water applied to heavy soils during hot weather should be regulated so that it will not stand too long, or provision should be made for draining off the surplus water and using it on some other part of the field.

Alfalfa seeded early in the fall usually makes some growth throughout the first winter. When these newly planted fields have a green growth of several inches on them during the winter months they should not be irrigated during periods of extremely cold weather. Comparatively warm irrigation water coming into contact with the frozen plants will thaw them out so quickly that all of the top growth may be killed, although the roots are apparently not injured and the plants soon start growing again. Frequently the new growth will be killed back on borders which have been irrigated on cold nights, while the plants on borders irrigated during the warmer part of the day remain green and thrifty. Such damage does not usually occur until the temperature is well below the freezing point.

The total amount of water required by an alfalfa crop for the entire season will vary with the soils, and with the amount and distribution of rainfall. In the Madera Valley, where the precipitation will average about 14 inches per year, approximately 48 inches of irrigation water is required to produce maximum crops of four or five tons per acre. This high water requirement is due to the high rate of evaporation and to the low humidity of this area.

MAKING HAY

The usual guide used in cutting alfalfa is the extent of blossoming. However, sometimes during the cool weather of early spring the first crop reaches the mature stage and new shoots start at the bottom although only a few blossoms are produced. When these new shoots start, it is time to harvest the crop regardless of the extent of flowering (Fig. 3). Under

Fig. 3.—To make hay of the best quality, alfalfa should usually be cut when about one-tenth of the plants are in bloom.

ordinary conditions the crop will make the most hay, of the highest quality, if cut when about one-tenth of the plants are in bloom. In an average season five cuttings are obtained.

During dry weather the leaves lose their moisture quickly and drop off when handled unless the rake follows the mower within a few hours, or

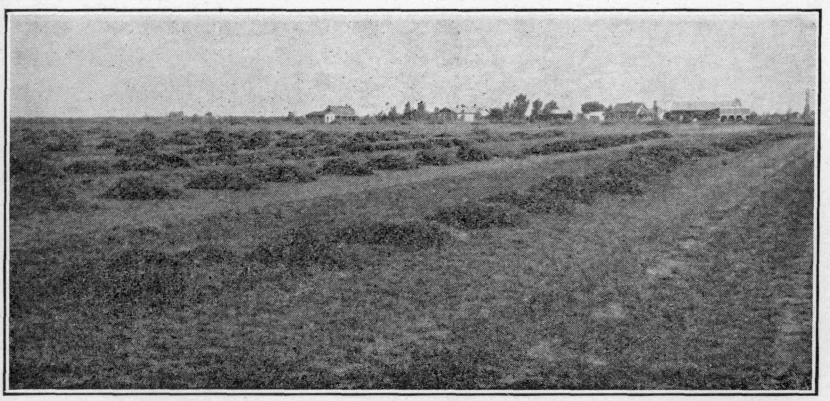

Fig. 4.—If alfalfa is bunched into small cocks more of the leaves will be retained and the hay will be of better quality than if allowed to become dry in the swath or windrow.

just as soon as the hay has wilted enough to pick up well. After lying in the windrow for a few hours it can be bunched into small cocks by running a sulky rake lengthwise of the windrow and then turning back in the opposite direction (Fig. 4). This places the hay in small cocks, which will cure with the loss of few leaves and with little exposure to the sun and dew. If the underside absorbs moisture from the ground, the cocks may be turned over very quickly with a sulky rake and allowed to cure on the under side. If the crop is to be baled from the field, a better quality

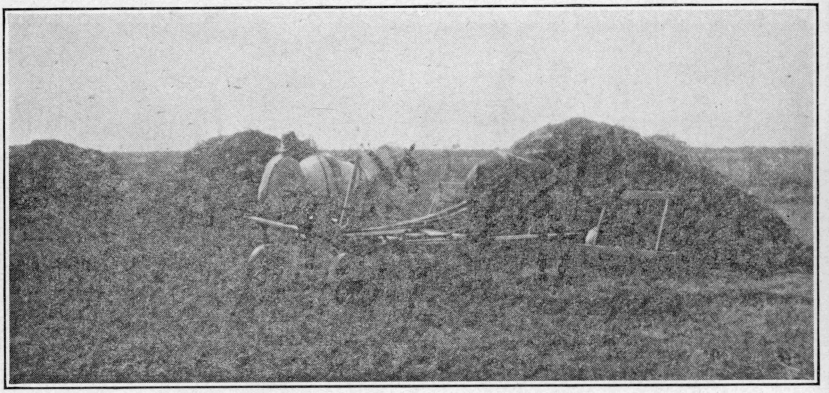

Fig. 5.—Alfalfa that has been "bucked up" in large bunches when nearly cured will remain in good condition for the baler.

of hay is usually made if the small bunches dumped by the sulky rake are bucked into large buck-loads as soon as well cured (Fig. 5). If these buck-loads stand a few hours, or overnight, the moisture from the inside of the

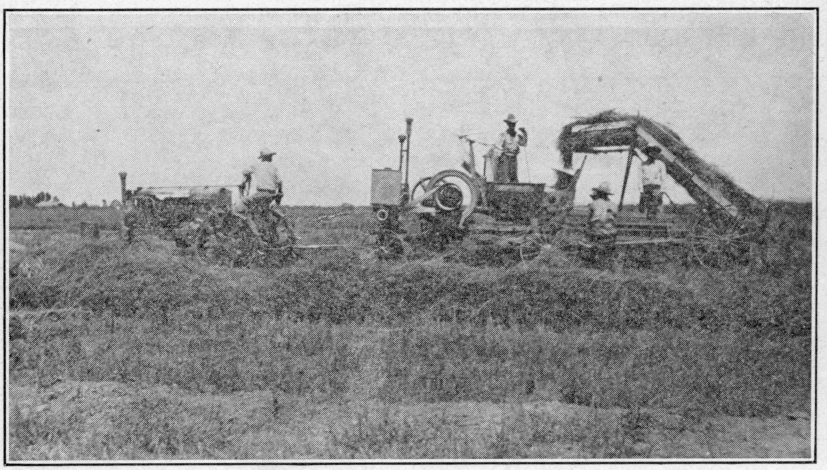

Fig. 6.—The self-feeding type of baler saves labor but should have greater capacity than some of those now in use.

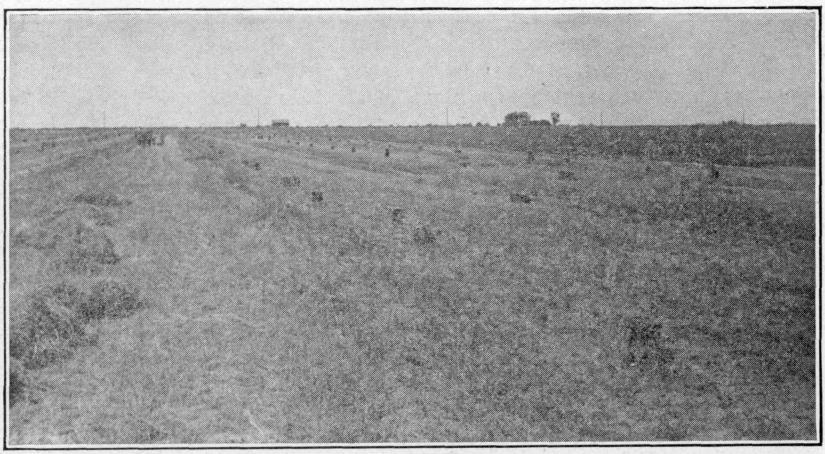

Fig. 7.—When baled directly from the windrow, the bales are scattered over the field and must be gathered up by trucks.

small piles toughens up the exposed hay and makes it bale better. If showers threaten before the crop is baled, these buck-loads can be "rounded up" with a fork and will be damaged very little by light rains.

During dry weather the crop is usually ready to bale about 36 to 48 hours after cutting. Bales should be uniform in size and shape and should be well tied. The bale should average a little under 60 pounds to meet with the approval of the retail merchant, who usually sells by the bale.

Within recent years there has been a growing interest in the use of labor-saving machinery, which has led to the development and use of the self-feeding type of baler which is drawn through the field by a tractor (Figs. 6

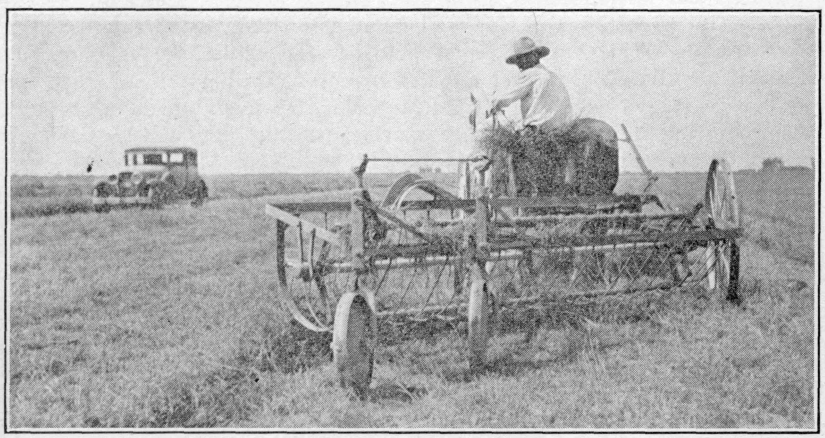

Fig. 8.—The side-delivery rake leaves only the stems of the alfalfa exposed in the windrow and insures even curing of the hay.

and 7). When this type of outfit is used, the alfalfa is raked with a side-delivery rake soon after beginning to wilt (Fig. 8). It is allowed to cure in the windrow and when ready to bale, the hay is picked up from the windrow by a loading attachment drawn along at the side of the baler. This method of handling hay requires more machinery but does not require as many men and, if baled at just the proper time, more leaves are saved, since the hay is handled less than when baled in the usual way. Since there are times when hay dries so rapidly that it could not be baled fast enough to prevent the leaves from dropping if allowed to remain in windrows, provision should be made for bucking up hay and baling from these buck-loads whenever weather conditions make this desirable (Fig. 9).

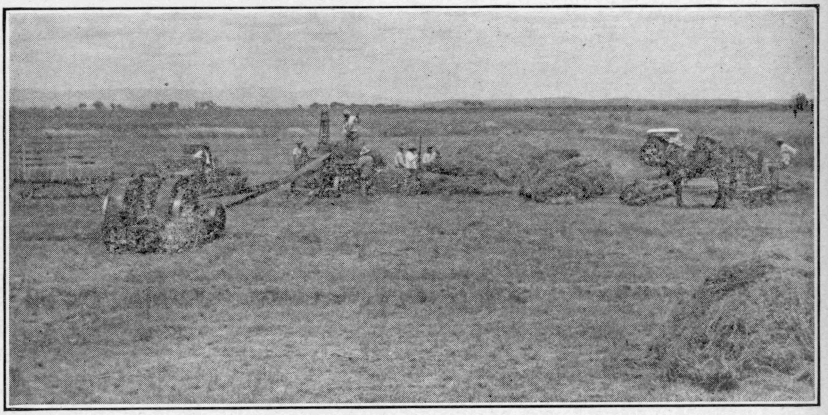

Fig. 9.—"Bucking" alfalfa from the windrow to the baler is a quick method of handling large quantities of alfalfa.

Alfalfa that is well cured in the field can be loaded directly on the cars and sent to market, but if not well cured it is likely to sweat, heat, and cause trouble. This kind of hay should be stored with the bales on edge in a well-ventilated barn and allowed to cure. During fair weather such hay can be staked edgewise behind the baler, leaving a space between the bales. During dry weather bales stacked in this way will lose a large amount of moisture in a day or two.

Alfalfa stored in an open shed or well-ventilated barn loses a large amount of weight within a few months, on account of further drying out in this dry climate. However, when stored in large quantities in adobe barns the loss is surprisingly small.

During the last few years most of the alfalfa produced on the irrigated lands of western Texas has been considered as a cash crop and has been marketed in central and eastern Texas or adjoining states. With the production of more home-grown feeds in these areas, however, there will probably be a decreasing demand for alfalfa from the West, and it is likely that a greater amount of this crop will be fed on the farms and ranches in the regions where it is produced.

If the crop were produced primarily for feeding it could probably be stacked directly on a feeding lot adjacent to the field at a considerable saving in labor charges. However, there would be some loss from weather damage, and market conditions might make it desirable to place the crop on the market. In this dry climate, alfalfa cannot be satisfactorily baled after standing in the stack for a long period, as the stems break up badly in going through the hay press and do not make attractice-looking bales.

With the increasing interest in the feeding of livestock in the West it is quite likely that a practice will develop of stacking where it can be fed directly to cattle or sheep without extra handling charges. This could be done very cheaply in many cases through the use of any one of several types of field stackers now available (Fig. 10).

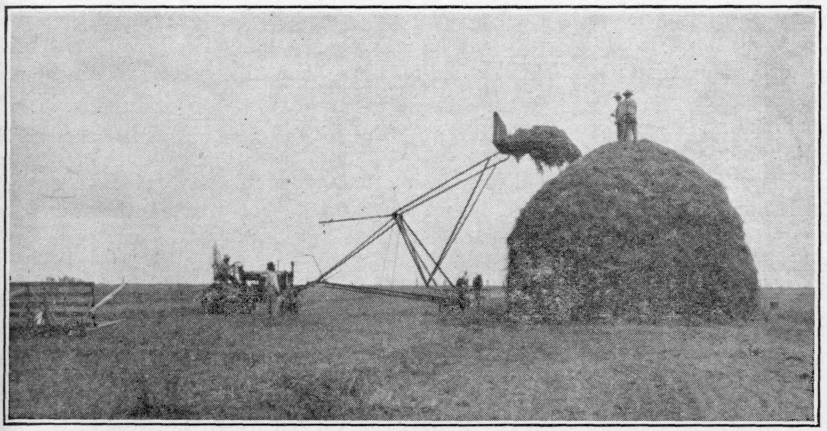

Fig. 10.—Alfalfa to be used for feeding purposes can be handled cheaply by any one of several different types of field stackers.

PRODUCTION OF SEED

Seed production depends largely upon climatic conditions during late summer. The second cutting is usually allowed to produce seed, if a seed crop is desired and conditions are favorable. The best seed crops are usually made on fields where the stands are not too thick, where the growth is not exceptionally heavy, and during seasons of light rainfall. If the weather is too hot and dry the flowers do not set well and if too wet, the crop makes a heavy vegetative growth at the expense of seed. When conditions are favorable, yields of 400 or 500 pounds per acre are often made. Occasionally yields of 600 to 700 pounds per acre are produced, but such yields are unusual.

PASTURING ALFALFA

When alfalfa is making a rapid, succulent growth it cannot be safely pastured by sheep or cattle, since it is likely to cause bloating of the ani-

mals. This is especially true if the alfalfa is wet with dew or rain, and if the animals are allowed to gorge themselves when hungry. However, many old fields containing more or less grass, are pastured during the summer months with few losses, but there is always some risk.

Frequently there is a considerable growth of alfalfa produced after the last cutting of hay in the fall. It is a common practice among farmers and ranchmen to pasture off this growth with sheep or cattle after it has been stunted and dried to some extent by freezing. Losses from bloating are much less common at this time of the year, but are more frequent with sheep than with cattle. During mild winters some growth is produced throughout the winter and if not pastured too heavily or too late in the spring, the permanent damage to the crop from pasturing is slight. On fields heavily infested with winter annual grasses, such as rescue grass, it is quite likely that pasturing off the grass until warm weather starts rapid growth of the alfalfa in the spring, will improve rather than damage the field, since it allows the alfalfa to get ahead of the grass.

Horses and mules are frequently allowed to run on alfalfa fields immediately after the alfalfa has been cut. Since they are not subject to bloating, as are cattle and sheep, they can often graze for several days along ditch banks, corners, and the levees on alfalfa that would otherwise go to waste. During the winter months horses are allowed to run over the fields. Little damage is done if fields are not pastured too heavily, but if feed is scarce horses will damage the crown of the plants by grazing too closely.

Alfalfa makes excellent hog pasture and a greater use should be made of the crop for the production of cheaper pork.

ALFALFA IMPROVES THE LAND

In western Texas where rainfall is light and the native vegetation scant, most soils are rich in mineral elements of plant food but are very low in organic matter and nitrogen. When irrigated, the tighter soils tend to run together and form crusts when drying, if not cultivated at the proper time. This is due largely to the lack of humus, or organic matter. These soils are greatly improved by growing alfalfa on them for a few years, and turning the stubble under for other crops such as cotton, sorghums, or grain crops. Growing alfalfa for five or six years has given increases of 20 to 30 per cent, or even 50 per cent, in yield of cotton over land not planted to alfalfa.

ROTATIONS FOR ALFALFA

In the planning of a farming program for any farm, the acreage should be divided up so that a legume crop is grown on a part of the land all of the time. A definite rotation should be established so that all of the expense of re-seeding to crops like alfalfa will not fall in the same year. An ideal rotation for conditions as they are in the Madera Valley, and

in many other sections, consists of five years of alfalfa, four years of a cultivated, or intertilled, crop, such as cotton or sorghums, followed by a fall grain crop of barley, oats, or wheat, seeded in the sorghum stubble or cotton stalks. This grain crop can be removed during early summer, giving ample time for working the land and getting it in shape for fall seeding of alfalfa. A farmer having 100 acres would have 50 acres in alfalfa, 40 acres in cotton or sorghums, and 10 acres in a fall grain crop which can be pastured or harvested for grain. Such a block of land would be divided into 10 blocks of 10 acres each. Ten acres of the oldest alfalfa would be plowed up each year and planted to cotton or sorghums, and the 10-acre block of grain would be seeded to new alfalfa. The grain would be planted on the oldest cotton or sorghum land and this would always be next in line for re-seeding to alfalfa.

With such a rotation once established, the alfalfa will always be in its prime, yields of cotton and sorghums will be much higher, and the expense of re-seeding to alfalfa will not be heavy in any one year. Since there are many weeds and new grasses now in the fields which did not cause trouble in the early years, it is usually best to plow up old fields in five or six years after seeding. These grasses and weeds can be killed out in about four years of clean cultivation and the land is then ready for alfalfa again. This system will make higher yields of crops and will distribute the labor during the year.

Such a rotation can be made flexible and can be adjusted to suit the local conditions and to allow for the planting of other crops when desirable, but it would be a good guide for most farms where cotton and alfalfa are the major crops. The practice of allowing alfalfa to stand until the field is entirely taken by grass and weeds is often costly.

FERTILIZERS FOR ALFALFA

Since the problem of soil fertility is local and varies with each farm, no general rule can be given for the application of fertilizers. Many soils of western Texas are fairly well supplied with the mineral elements, phosphoric acid and potash, and on rich soils crops do not respond to applications of fertilizer supplying these elements. However, there are irrigated soils in some sections which give increased yields of alfalfa when fertilized with superphosphate. Results obtained from applications of superphosphate in parts of the Pecos Valley, around Fort Stockton, and on some of the soils in the vicinity of Pecos, indicate that some of these soils are low in available phosphoric acid; hence increased yields of alfalfa are obtained from its use.

Applications of superphosphate to soils on Substation No. 9, Balmorhea, have given some increase in yields of alfalfa when the crop was well supplied with water. During seasons when there has been a shortage of water there is no increase in yield, since moisture is the factor which limits the yield under these conditions. Applications of potash and sulphur have had no appreciable effect upon the yield of alfalfa at Balmorhea.

The yields of alfalfa obtained from plats receiving different amounts of superphosphate, muriate of potash, and sulphur in 1927 are presented in Table 2. These yields are low and the figures should not be given too much weight, since all plats in this experiment suffered severely from cotton root rot.

Table 2—Yield of alfalfa under various fertilizer treatments at Balmorhea, Texas, 1927

Kind of fertilizer	Yield in tons of hay per acre
None	3.00
600 lbs. superphosphate	4.43
400 lbs. superphosphate	4.64
200 lbs. superphosphate	3.85
250 lbs. muriate of potash	2.95
125 lbs. muriate of potash	2.92
1000 lbs. sulphur	2.88
500 lbs. sulphur	2.92
600 lbs. superphosphate, 250 lbs. muriate of potash, 1000 lbs. sulphur	4.45

The yields on the same plats in 1928 are presented in Table 3. These figures indicate that the yield of alfalfa is increased to some extent by applications of superphosphate but the variation in stand of plants, due to attacks of the root rot fungus, makes it necessary to consider these relative yields as an indication of what may be expected from applications of superphosphate on large acreages rather than as a definite measure of the

Table 3.—Yield of alfalfa under various fertilizer treatments at Balmorhea, Texas, 1928

Kind of fertilizer	Yield in tons of hay per acre
None	2.17
300 lbs. superphosphate	3.46
200 lbs. superphosphate	3.30
100 lbs. superphosphate	2.46
250 lbs. muriate of potash	1.83
125 lbs. muriate of potash	1.88
300 lbs. superphosphate, 250 lbs. muriate of potash	3.11

value of superphosphate. On soils which have not shown a need for commercial fertilizers, they should be tried out in a small way before large sums are spent in buying plant food which may not be needed.

WEEDS IN ALFALFA FIELDS

Johnson Grass (*Andropogon halepensis*) is one of the most serious weed pests of alfalfa in many of the irrigated sections. Many of the irrigation ditches are filled with the grass, which is often allowed to produce seed, which are carried down to irrigated fields with the water. These seeds then sprout here and there over the field and each spot soon spreads out

by underground stems until in a few years the hay produced on such fields is largely Johnson grass. The rate of spread varies with the nature of the soil and the number of seed crops which are produced. Cutting hay crops at intervals of thirty to thirty-five days will help to hold the grass in check but if seed crops are allowed to grow over periods of two months, the Johnson grass roots are given a much better chance to spread.

On clean fields which are seeded to alfalfa the Johnson grass could probably be kept out if all bunches of grass were pulled out as they show up after an irrigation and while the ground is still soft. These young plants do not have deep underground stems and can be pulled out by the roots when the soil is wet. As fields become badly infested with Johnson grass they should be plowed up and planted to other crops which can be given clean cultivation for three or four years. They can then be re-seeded to alfalfa after the grass has been killed out.

Small patches of Johnson grass can be killed out by spraying with sodium chlorate, or calcium chlorate—one pound per gallon of water. A second application of spray to shoots which start out again after a few weeks, has been fairly effective in killing out small areas. The spray should be applied about the time that the heads are coming out of the boot in order to be most effective.

Close pasturing of Johnson grass fields by sheep has been an effective means of ridding some fields of the grass. A season of close pasturing brings the underground stems close to the surface and they are easily killed by plowing and exposing them to either the hot sun of midsummer, or the freezing and drying of the winter season. In the extreme western part of the state where rainfall is light, the grass is much more easily killed than in sections having more rainfall.

Bermuda Grass is not as serious a pest in western Texas as it is in the more humid sections of the State. Where the rainfall is very light, it can be killed out easily on cultivated fields. Bermuda grass, however, is hard to eradicate in irrigation ditches and will gradually spread to the alfalfa near the ditches and finally all over the field. New areas are apparently started throughout the field by seeds which germinate here and there, especially in vacant spots. The grass will gradually choke out alfalfa but does not get tall enough for hay, so that ground covered with this grass produces very little. The Bermuda grass on these fields can be readily killed out by rotating with a clean cultivated crop for a few years. Plowing during cold, dry weather in the winter will usually kill a large part of the grass, which is shallow-rooted and cannot stand much freezing or drying after being plowed up. The grass is more troublesome on sandy land than on tight land but can be easily killed out by rotation of crops.

Rescue Grass (*Bromus unioloides*): During the past few years many fields of alfalfa have been infested with rescue grass, during the winter. Rescue grass is a winter annual which comes up in the fall, grows through the winter, and seeds in the early spring. It produces a large amount of pasturage during the winter months and alfalfa fields heavily infested with the grass should be pastured through the winter months until the time alfalfa starts growing actively in the spring. This practice of grazing

will aid in preventing the rescue grass from making seed and thus allow the alfalfa to get ahead of the grass when the weather warms up. Fields heavily infested with rescue grass are not likely to keep their full stands long, as the grass gradually chokes out the alfalfa; such fields should soon be plowed up and planted to some summer cultivated crop.

Blue Weed (*Helianthus ciliaris*) is sometimes troublesome in cultivated fields but seldom gives trouble in fields planted to alfalfa. Apparently alfalfa plants are able to choke out the blue weed if a good stand of alfalfa is established.

Little Barley (*Hordeum pusillum*) is a winter annual grass which germinates in the fall, grows through the winter, and produces a very heavy crop of seed early in the spring. The plants then die, the seed germinate in the fall, and another crop of grass is produced during the winter months. This grass is not relished by livestock, either as hay or as green pasture, and it has little value. Rotation of alfalfa with cultivated crops is the most practical method of control.

Dodder: When alfalfa seed from some unknown source is purchased it frequently contains seed of the parasite, dodder. If planted in the fall of the year, many of the dodder seed will germinate with the alfalfa and be killed by cold weather during the winter. However, many will remain dormant until spring and germinate. The dodder seedling has a temporary root which grows in the soil until the upper viney, yellow growth of the dodder plant can attach itself to a growing alfalfa plant. It then feeds on the alfalfa plant and the root in the soil dies. When once established dodder grows rapidly from one alfalfa plant to another, sucking the juices from the plants and producing a heavy crop of dodder seed to spread the pest. As soon as these yellowish-red areas are noticed in a field they should be cut close to the ground with a scythe or hoe and burned on the spot before they have time to mature a seed crop. If they are allowed to go until the alfalfa crop is harvested for hay or seed the dodder will make seed and, consequently, may spread over large areas.

When purchasing alfalfa seed for planting one should know that they are free from dodder, but, if seed containing dodder is planted unknowingly the dodder can be eradicated by close cutting of the infested areas and burning before the dodder produces seed.

INSECT PESTS OF ALFALFA

The insects which frequently do damage to the alfalfa hay crop are the garden webworm, alfalfa caterpillar, pea aphid, grasshoppers, stink bugs, and blister beetles. Many other insects are present in the fields but usually do no serious injury.

The Garden Webworm (*Loxostege similalis*) visits this section of the state periodically every few years. When present it usually attacks the third and fourth cuttings of alfalfa, eating up the foliage on the upper parts of the plants, including the growing buds, and spinning webs over the plants. The ravages of the pest reduce the yields, retard growth of the crop, and lower the quality of the hay. When the worms are numerous and the damage severe, the crop should be harvested and the field exposed

to the sun and to birds which feed upon the worms. Prompt application of irrigation water will start the next crop and often get it ahead of the second brood of worms. The garden webworm has done serious damage to the alfalfa crop in the vicinity of Balmorhea in only two of the eight years, 1923 to 1930, inclusive, and is not a big factor in alfalfa production.

The Alfalfa Caterpillar (*Eurymus eurytheme*), or long green measuring worm, produces the familiar yellow butterflies present in alfalfa fields during midsummer. It does not usually do much damage in this part of the State, but occasionally this insect severely injures a crop. During the summer months the worms are always present in fields and are sometimes confused with the webworms, which do most of the damage when they are present. If injury should become serious, the crop should be cut and the field cleaned off. This will usually reduce their numbers and hold them in check until the next crop is well started. Serious damage from any kind of caterpillars is usually confined to the third and fourth cuttings and this damage can be lessened by early harvesting of the crop.

Grasshoppers occasionally become so numerous that they do some damage to alfalfa crops, especially on the outer edges of fields and on fields adjacent to dry-land pastures, which furnish breeding grounds for the insects. Injury to seed crops is rather severe sometimes, due to the cutting off of the seed-producing branches. The use of poison bran mash will aid in controlling the grasshoppers if made up and used according to the recommendations of entomologists. The following formula, with slight variations, is used in many sections with good results although complete control over a wide area is rather difficult:

Bran	100 pounds
Salt	5 pounds
White arsenic	5 pounds
Amyl acetate (banana oil)	3 ounces
Cheap molasses	2 gallons
Water	about 10 gallons

Blister Beetles: During some seasons the various kinds of blister beetles become troublesome on alfalfa and do some damage, but serious injury is usually confined to small areas. No control measures are recommended, since the small amount of injury will not usually justify the use of poisons for controlling the beetles. There are large numbers of different kinds of these insects but all are difficult to control except by the application of poisons directly to the crop; besides, injury is more serious on other crops such as beets and peppers, which they prefer when available.

Pea Aphid: Sometimes when mild winters are followed by cool springs, the alfalfa makes a quick early growth, which is retarded later. Under these conditions the pea aphid (*Illinoia pisi*) multiplies in such numbers that injury is serious to the first cutting. Fortunately these conditions do not prevail often in this part of the State and the loss is usually confined to the first cutting of certain areas, and to seasons when cool spring weather follows a mild winter. Under these conditions the insects multiply very rapidly while their natural enemies increase slowly. This allows the

aphids to get a good start, but they do not thrive during hot dry weather and soon disappear when the cool weather of early spring changes to dry, hot summer weather.

Handling the crop in such a way that it will make the most rapid, thrifty growth will aid in reducing the extent of injury from the aphids. Outbreaks of the pea aphids are sporadic and little can be done except to force the crop to outgrow the injury whenever possible.

The Stink Bug: If present in great numbers the stink bug (*Chlorochroa ligata*) sometimes does much damage by puncturing the immature pods of a seed crop. These insects have sucking mouth parts with which they puncture the seed pods and suck out the juices. This causes a blighting of the pod and reduces the yield of seed. No specific remedy is known which would be practical except that of keeping fields, roads, ditches, and fence rows cleaned up as much as possible. This will reduce the number of insects which survive the winter, and will help in holding them in check during the summer months. This insect also does considerable damage by sucking the juices from immature grain sorghum seeds and from young cotton bolls.

DISEASES OF ALFALFA

Observations covering the behavior of the cotton root rot fungus, and suggestions for lessening its injury to alfalfa fields, are intended to cover only the irrigated sections of western Texas having soil and climatic conditions similar to those at Balmorhea.

Cotton root rot: The cotton root rot disease (*Phymatotrichum omnivorum*) is one of the most injurious diseases affecting alfalfa in many parts of the irrigated sections of the Southwest. The fungus is present on many weeds and shrubs of the native vegetation in this region and when the lands are put into cultivation the fungus is there to attack any susceptible crop. It was observed in opening up the Station lands that as these lands were put into cultivation there was a gradual dying out of the fungus so that after a few years in alfalfa and cotton the damage is much less than during the first two years after clearing the land. This appears to be the experience of many farmers.

The fungus is prevalent on the low-growing, tuber-producing plant *Hoffmanseggia densiflora.* This is a perennial weed, widely distributed in western Texas and is difficult to eradicate in irrigation ditches. The fungus seldom kills this weed out entirely but lives on the roots of the weed and spreads to alfalfa, or any susceptible crop, growing in fields adjacent to these ditches.

In the case of alfalfa the greatest injury occurs during June, July, and August of the summer following fall seeding on virgin land. During this season the spots of infection are usually small but numerous and widely scattered. The plants have not become strong enough to revive easily if the tap roots are rotted off, and many are killed. If the field is irrigated often enough during this first year to keep the soil from getting too dry, many of these affected plants will send out new roots and recover. This is also true of old fields which are infested. If they

are allowed to become too dry many infected plants having no tap roots will be killed, while if irrigated more frequently they will produce new roots and recover. On sandy soils these new roots appear to go down deep into the subsoil, but on tighter soils they remain closer to the surface. On infected plants the tap root is usually cut off at a point two to four inches below the crown and these new roots are sent out above that point.

Alfalfa varieties, such as the Hairy Peruvian, having strong central tap roots and less tendency to send out branching roots, are much more easily killed out than those varieties, such as the common alfalfa, which send out side roots freely when the tap root is affected. For this reason the Hairy Peruvian variety is short-lived when planted on ground infested with this fungus. The best strains of the common variety will hold a stand much longer under these conditions.

There are probably no varieties which are entirely immune to this disease. More than 50 different strains and varieties from different parts of the world have been grown at the Experiment Station, Balmorhea, over a period of several years. All of these have been infected, but those having branching root systems, or the ability to send out new roots, have suffered much less than the Hairy Peruvian and similar varieties.

The fungus spreads most rapidly during periods of warm, moist weather during late summer, but usually does its greatest damage to alfalfa when there is a shortage of soil moisture. This is due to the fact that the infected plants are unable to make new roots with which to survive.

In the spring of 1925, 20 plats were laid out for the purpose of deter-

Table 4.—The effect of fallow on control of root rot, Substation No. 9, Balmorhea, Texas

Plat No.	Treatment during the year					Estimated percentage of area infested with root rot in the fall of 1929
	1925	1926	1927	1928	1929	
1*	fallowed	fallowed	fallowed	fallowed	alfalfa	1%
2*	fallowed	fallowed	fallowed	fallowed	alfalfa	1%
3	alfalfa	alfalfa	alfalfa	alfalfa	alfalfa	5%
4	alfalfa	alfalfa	alfalfa	alfalfa	alfalfa	5%
5	fallowed	fallowed	fallowed	fallowed	alfalfa	5%
6	fallowed	fallowed	fallowed	fallowed	alfalfa	5%
7	fallowed	fallowed	fallowed	fallowed	alfalfa	5%
8	fallowed	fallowed	fallowed	fallowed	alfalfa	5%
9	fallowed	fallowed	fallowed	fallowed	alfalfa	5%
10	fallowed	fallowed	fallowed	alfalfa	alfalfa	10%
11	fallowed	fallowed	alfalfa	alfalfa	alfalfa	10%
12	fallowed	alfalfa	alfalfa	alfalfa	alfalfa	10%
13	weeds	alfalfa	alfalfa	alfalfa	alfalfa	10%
14	weeds	weeds	alfalfa	alfalfa	alfalfa	10%
15	weeds	weeds	weeds	alfalfa	alfalfa	15%
16	weeds	weeds	weeds	weeds	alfalfa	15%
17	weeds	weeds	weeds	weeds	alfalfa	15%
18	weeds	weeds	weeds	weeds	alfalfa	15%
19	weeds	weeds	weeds	weeds	alfalfa	15%
20	weeds	weeds	weeds	weeds	alfalfa	15%

* Plats Nos. 1 and 2 were irrigated often enough to keep the subsoil moist throughout the period of fallow.

mining the length of time necessary to kill out the fungus by means of clean fallow. The treatments for the years 1925 to 1929 are presented in

Table 4. The results of the test show that it is difficult, under conditions existing at Balmorhea, to starve out the fungus within a reasonable length of time by means of clean fallow. Irrigated fallow is apparently more effective in eradicating the fungus than is dry fallow. Probably equally good, or better, results would be secured through the use of a sorghum or grain crop, and the land would not be idle.

SUMMARY

No other legume crop now grown is equal to alfalfa in the sections of Texas to which this crop is best adapted, and the acreage should be increased in many areas.

Alfalfa thrives best when grown on deep loam soils having good drainage.

Relatively high temperatures and low humidity favor its growth if the soil is kept well supplied with moisture by frequent irrigations.

The border method of preparation of land for alfalfa is most satisfactory when the land is smooth enough to permit of its use.

Good stands of alfalfa are nearly always obtained by planting 16 to 20 pounds of seed per acre on well-prepared land about September 15 to 20. One-half of the seed should be broadcast each way to insure uniform distribution and should be sown on soil which has been slightly roughened with a smoothing harrow. The seed is covered by flooding and the field is re-watered in about four days.

Where irrigation water is not available for re-watering fields, planting by the drill method would be preferable.

In sections having very low rainfall about 48 inches of irrigation water per season is required to produce maximum crops of four to five tons per acre.

Alfalfa should usually be cut when about one-tenth of the plants are in bloom, and should be raked or bunched into small piles before the leaves are dry enough to shatter.

The best seed crops are obtained during relatively dry seasons, when the vegetative growth is retarded.

During the winter season alfalfa furnishes a considerable amount of pasture for all classes of stock but when the crop is growing vigorously the tender growth is likely to bloat cattle and sheep. The danger is greatest when the foliage is wet from dew or rain.

Alfalfa improves the soil by adding nitrogen and organic matter and yields of other crops are almost invariably increased when they follow alfalfa.

Johnson grass, Bermuda grass, rescue grass, little barley, and dodder are among the worst weed pests in alfalfa fields.

The garden webworm, grasshopper, and alfalfa caterpillar are among the worst insect pests attacking alfalfa in west Texas.

When the fungus is present in the soil cotton root rot is one of the worst diseases affecting alfalfa. Rotations including sorghums and grain crops, preceding alfalfa, appear to be just as effective as clean fallow in ridding the soil of the fungus in western Texas. Clean fallow over a period of one or two years cannot be depended upon to give effective control.